

THE PLEIADES OPEN CLUSTER

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1 Introduction

Open clusters are groups of stars close each other, gravitationally bound and moving together in space as a unique system. In the Milky Way astronomers have observed about 300 open clusters. They are called “open” due to their shape, compared with the globular clusters. Open clusters are less concentrated, contain few hundreds stars and are less gravitationally bound than globular clusters. The most known and the easiest to recognize is the Pleiades cluster, observable by naked eye.

Star clusters are important to study stellar evolution. The stars belonging to a cluster originate from the same gas cloud, so they have the same age and initial chemical composition.

In this tutorial we will learn how to use Aladin to visualize the parallax of stars, useful to understand if a star belong to a cluster or does not. Then we will build the color-magnitude Hertzsprung-Russell diagram to study the cluster evolution.

2 Parallax

Astronomers use parallax to measure the distance of stars. The parallax is the angle between the directions we observe a near star, with respect the background stars, when seen from two different positions.

The parallax is smaller more the star is distant from us, and larger more the star is close. In order to see a small difference in the position of a star when

observed from two different locations, such locations have to be very distant each other. Two people located at a few kilometers would not note difference. The only way to measure stellar parallax is to observe the star from two opposite points of the Earth orbit. Astronomers compute the position of the star once every six months, from two points far 300 millions kilometers (the diameter of the Earth orbit). The angle between the two positions of the star with respect the background is called “annual parallax” of the star.

Astronomers use the “parsec” to compute distances of stars. One parsec is the distance from which the radius of the Earth orbit is seen under an angle of

one arcsec. A star far one parsec from us has a parallax of one arcsec. An arcsec is the angle under which you would see a soccer ball 46 km far.

3 Stellar evolution

To study star evolution astronomers use the Hertzsprung-Russell diagram, which represents absolute magnitude of stars versus their spectral type. The Hertzsprung-Russell diagram of a cluster is easy to build because we can use apparent magnitude instead of absolute magnitude: we do not need information on distances.

Stars belonging to a cluster are all at the same distance from us, they originate at the same time and from the same gas cloud. Hence they have the same

age and initial chemical composition: the differences in luminosity between the members of the same cluster are due only to the mass of stars. This fact makes stellar clusters very useful to studying stellar evolution.

Looking at the Hertzsprung-Russell diagram of a cluster we can see that most stars lie in a limited region of the diagram, called the “main sequence”. This fact suggest that color and magnitude are not casual. More massive stars begin to move towards the giant branch: astronomers use the end point of the main sequence to compute the cluster age. The Hertzsprung-Russell diagram is the cornerstone of our knowledge on stellar structure and evolution.

4 Aladin

Aladin is an interactive sky atlas developed and maintained by the Centre de Donnes astronomiques de Strasbourg (CDS) for the identification of astronomical sources through visual analysis of reference sky images.

Aladin allows the user to visualize digitized images of any part of the sky, to superimpose entries from the CDS astronomical catalogues and tables, and to interactively access related data and information from various data servers (like SIMBAD, NED, Vizier).

Aladin is a Java application available from <http://aladin.u-strasbg.fr/>.

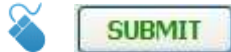
5 Load the image of the Pleiades

Our aim is to study the properties of stars belonging to Pleiades. We start loading in Aladin an image of the Pleiades and a catalog.

Open the server selector window:

File --> Load astronomical image
--> Aladin image server

In the field “target” enter “pleiades”, in the field “radius” enter “30 arcmin”.



NOTE: In this tutorial when you find the mouse icon it means you have to click the following button.

Select the image “POSS II J 6.5 x 6.5 deg”.



POSS is the acronyms of Palomar Observatory Sky Survey: it is a collection of digitalized photographic plates covering all the sky, taken at the Palomar Observatory. All these images are astrometrically calibrated, i.e. coordinates have ben assigned to each point.

Then we choose “The Hipparcos and Tycho Catalogues” which contains also data on parallax, measured by the Hipparcos satellite.

In the server selector window (fig. 2) (in the right column)



In the field “Author, free text” enter “parallax”.



Select “ I/239” (The Hipparcos and Tycho Catalogues, fig. 1) and return in the server selector window. In the filed “catalog” “I/239” appears, to avoid to load more than one table add “/hip_main” (fig. 2). In the field “Radius” enter “5 deg”.



Name	Category	Density	Description
I/196	optical	2	Hipparcos Input Catalogue, Version 2 (Tur...
I/238A	optical	2	Vale Trigonometric Parallaxes, Fourth Edi...
I/239	optical	2	The Hipparcos and Tycho Catalogues (ESA 1...
I/256	optical	2	Catsberg Meridian Catalogs (CMC, 1999)
I/280A	optical	2	All-sky Compiled Catalogue of 2.5 million...
J/AN/325/740	optical	2	Astrophysical supplements to ASCC-2.5 (Ph...
I/62C	optical	1	Pertch 70: Positions of 24800 Stars (Hog+...
I/99	optical	1	Broerfælde Meridian Catalogues 1964-1976 (...)
I/143	optical	1	Fourth Fundamental Cat and Suppl. (FK4, FK...
I/144	optical	1	First, Second and Third Herzsprung-Russell...
I/250	optical	1	The Tycho Reference Catalogue (Hog+ 1998)
I/311	optical	1	Hipparcos, the New Reduction (van Leeuwen...
III/254	optical	1	2nd Cat. of Radial Velocities with Astrom...
V/32A	optical	1	Stars within 25 pc of the Sun (Woolley+ 1...
V/36B	optical	1	Supplement to the Bright Star Catalogue (...)
V/50	optical	1	Bright Star Catalogue, 5th Revised Ed. (H...
V/53A	optical	1	Catalogue of the Brightest Stars (Gschenk...
V/70A	optical	1	Nearby Stars, Preliminary 3rd Version (Gl...
V/109	optical	1	SKY2000 Catalog, Version 4 (Myers+ 2002)
J/A+A/381...	optical	1	Astrometric Radial Velocities. III. (Mads...

Figure 1: List of catalogues available in Aladin.

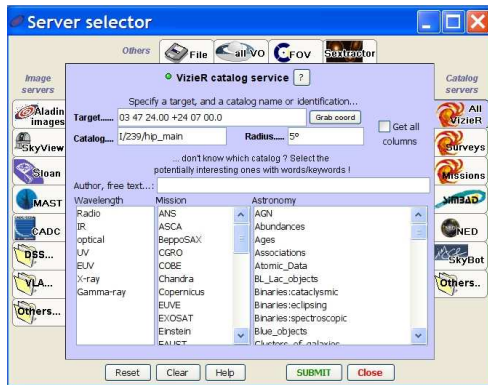


Figure 2: The image and catalog selector window of Aladin

6 Compute the histogram of parallax

Open VOPlot from the menu

Tools --> VO Tools --> VOPlot

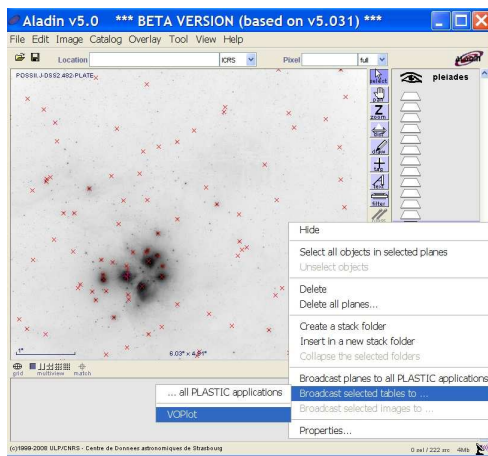


Figure 3: Broadcast data to VOPlot.

Right click on the plane of the catalog and broadcast the data to VOPlot through (fig. 3):

Broadcast selected tables to --> VOPlot

Move in the VOPlot window (fig. 4).

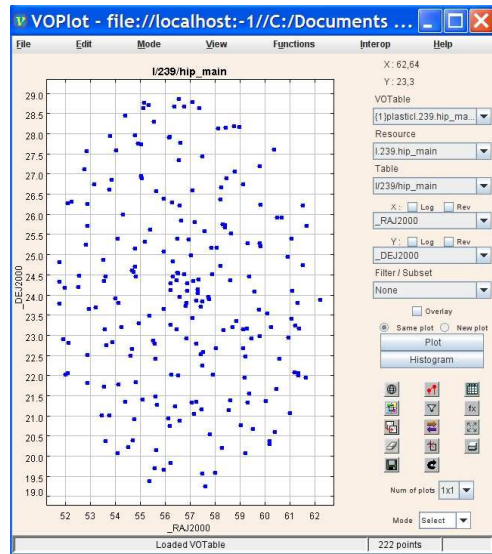


Figure 4: Main window of the VOPlot tool.

In the field “X coordinate” select “parallaxes” (plx)



The plot in figure 5 appears. It represents the histogram of parallaxes of stars of the Pleiades image loaded in Aladin.

Looking at the plot we can see that the parallax of the Pleiades cluster is around 8-9 mas (milliarcsec), that there are many background stars (smaller parallax) and a few foreground stars (larger parallax). The real value of Pleiades parallax is 8.46 ± 0.22 mas.

7 Visualize the Hertzsprung-Russell diagram

In order to correctly build the H-R diagram we have to correct data for reddening. We use the expression $(B-V)_0 = (B-V) - E(B-V) = (B-V) - 0.04$ for this cluster. The reddening is the effect of matter in the universe between us and the Pleiades (see the box).

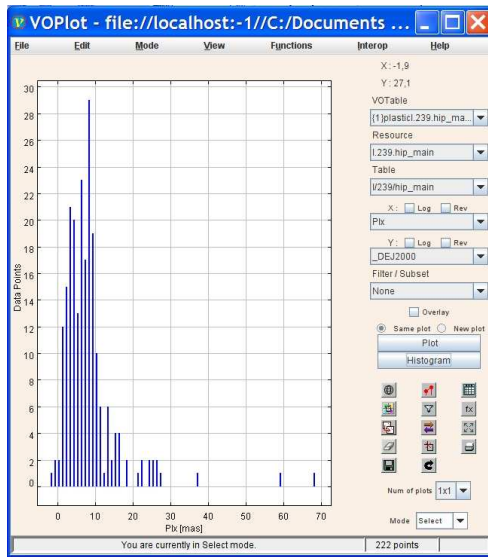


Figure 5: Histogram of parallaxes of stars in the Pleiades image.

REDDENING

Reddening is one of the effects caused by the interstellar medium: blue light is absorbed and scattered more than red light. As a consequence the color index B-V (the difference between the magnitude in B band and the magnitude in V band) increases. Reddening is due to the grains of dust of the interstellar medium, between us and the Pleiades. Grains of dust absorb and scatter the light with wavelength comparable with their size: longer wavelengths (blue light) are largely absorbed and scattered, while shorter wavelengths (red light) can easily pass through the interstellar medium.

We add a new column in the catalog, with the correct values. Select the catalog plane and open the menu

Catalog --> Add a new column

In the field “Name” enter “(B-V)₀”. In the field “Expression” enter “\$(B-V)-0.04” (fig. 6).

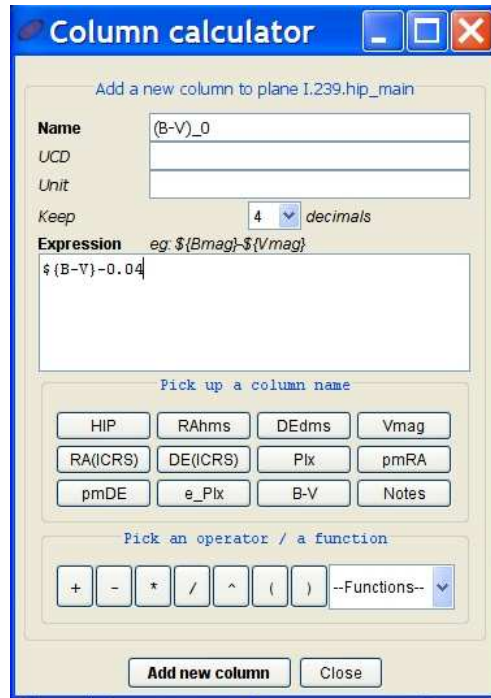


Figure 6: The window to add a new column.

Select some stars of the image and look at the table in the lower part of the Aladin window. Move the scroll bar to the right and verify the new column (B-V)₀ has been added.

Broadcast the plane of the catalog to VOPlot as done before (fig. 3) and move in the VOPlot window. In the field “X coordinate” select “(B-V)₀”. In the field “Y coordinate” select “Vmag”. Check the option “rev” of the Y axis (fig. 7).



The Hertzsprung-Russell diagram of the Pleiades appears in the VOPlot window (fig. 7), it is easy to recognise the main sequence. If you select some points in the plot the corresponding stars are highlighted in the image loaded in Aladin.

In order to know if some stars belong to the cluster we have to select them and look at their parallax in the table loaded in Aladin. Select the points up left in the plot (brightest stars) and note that they

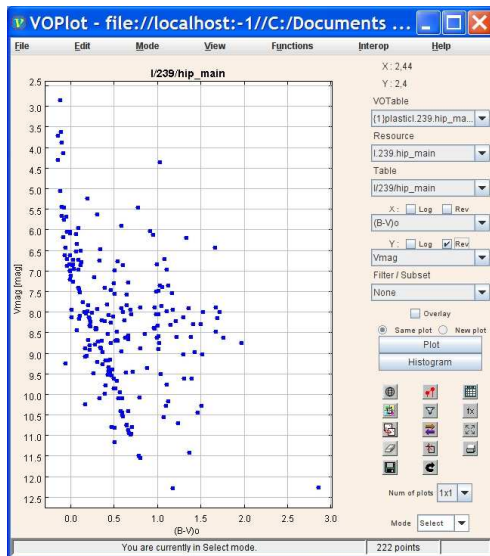
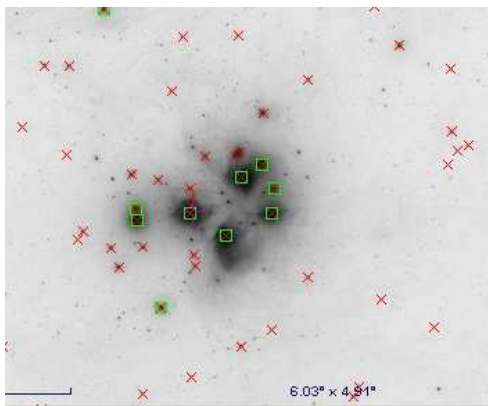


Figure 7: The Hertzsprung-Russell diagram of the Pleiades cluster.

correspond to the central stars of the image. From the data in the table you can see that their parallax is 8-9 mas: they belong to the Pleiades. Now select some points bottom right (faintest stars) in the plot: they correspond to stars at the edge of the image. Looking at the parallaxes they are most background stars (smaller parallax) and a few foreground stars (parallax ~ 8).



THE END